PFC-20
PFC-30
&
PFC-40
Series Chargers

Owner's Manual

Rev 1.1

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PFC-20/30/40 SERIES
BATTERY CHARGER
MANUAL rev 1.1

General Overview

The Manzanita Micro PFC chargers are a unique group of powerful, efficient battery chargers. The chargers will run off any voltage from 100 up to 240 volts AC. The chargers can be set to run automatically when plugged in, yet they also have far more user adjustable functions than other electric vehicle chargers. Every model is user adjustable to charge batteries from 12 to 450 Volts DC. All the chargers are power factor corrected and are available with enhanced options such as an AC input current display. With so much flexibility and models from 20 to 75amps, your PFC charger may be the last charger you ever need to buy.

Speed and Efficiency

The essential ingredient for fast recharge times is to deliver high power to the battery. The key to polite opportunity charging is to be able to share outlets with other equipment and make efficient use of limited current. The Manzanita Micro PFC line of chargers has an adjustable current throttle knob to allow the chargers to be turned down to operate on very limited power sources. Efficiency and power factor are both better than 0.9.

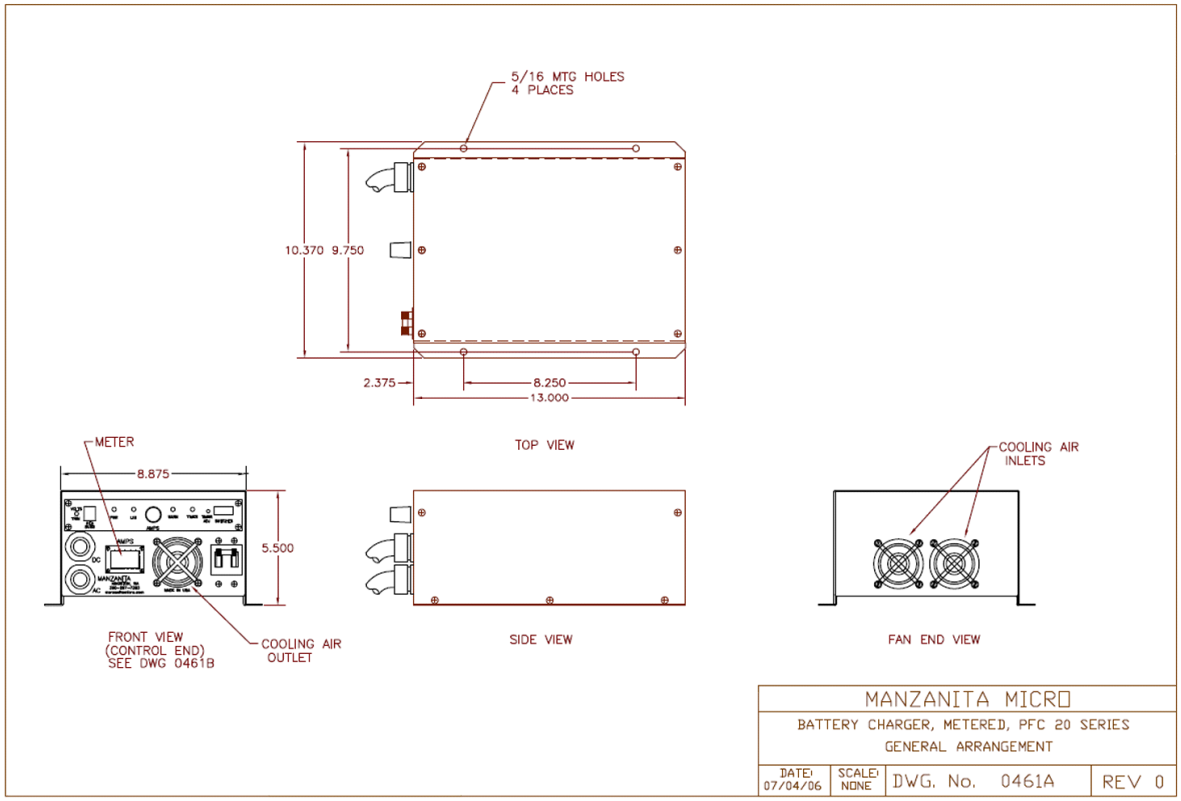
What does the PFC mean?

In the Manzanita Micro chargers PFC stands for Power Factor Corrected. This means that current and voltage are drawn in unity, (ie: current is drawn with unity to the incoming line voltage).

PFC-20/30/40 SERIES
CHARGER FEATURES

- Power Factor Corrected
- Every charger easily runs on 110/120V and 220/240V
- Easy ‘Amps’ adjustment knob allows users to quick-tune the charger to pull maximum amps from the incoming power source
- User adjustable peak charge voltage allows users to adapt charger to any battery voltage from 12 to 450 volts
- Up to 9,600 watts of power from a unit that weighs less than 20 lbs (9kg) and is about the size of a shoe box
- Reg bus port for easy integration with Manzanita Micro BMS (also compatible with other Battery Management Systems)
- Self regulating thermal protection
- Active variable speed fan cooling
- Water cooling option
- Input line current meter option
- Adjustable absorption phase (end of charge) timer function
- Ability to enable auto restart mode
- Ability to enable timed charging mode
- Standard PFC-20 and PFC40HM (PHEV) models can run on both AC or DC voltage (* Buck enhanced models can also run on DC if modified)
- Now with a latched timer mode
- Float charge option available

Dimensions and Specifications



The PFC-20, PFC-30 and PFC-40 series chargers weigh in at approximately 18 pounds (8.2 kg)

The outermost dimensions including foot flanges are approximately 14” L x 10.5” W x 5.75” H (358mm x 264mm x 145mm)

Input Voltage Range : 100 to 240VAC 40-80Hz computer grade pure sine wave

Output Voltage Range : 12 to 450VDC (+/- 1 volt)

Operating Temp Range : -20° F to +120° F (-28.8° C to +48.8° C)

Power Consumption : Up to 9.6kW ~ PFC40 / 7.2kW ~ PFC30 / 4.8kW ~ PFC20

The 20, 30 or 40 nomenclature is indicative of how many amps that charger is rated to draw from the AC line. Unlike some other chargers, this is the rated continuous load and all units are thoroughly tested to their rated limits before leaving Manzanita Micro. An optional panel mount current meter is available which displays the amount of current (amps) that the charger is drawing off the AC line. This allows the user to tune the charger precisely for the maximum allowable amps for the outlet they are plugged into.

Charger Operation

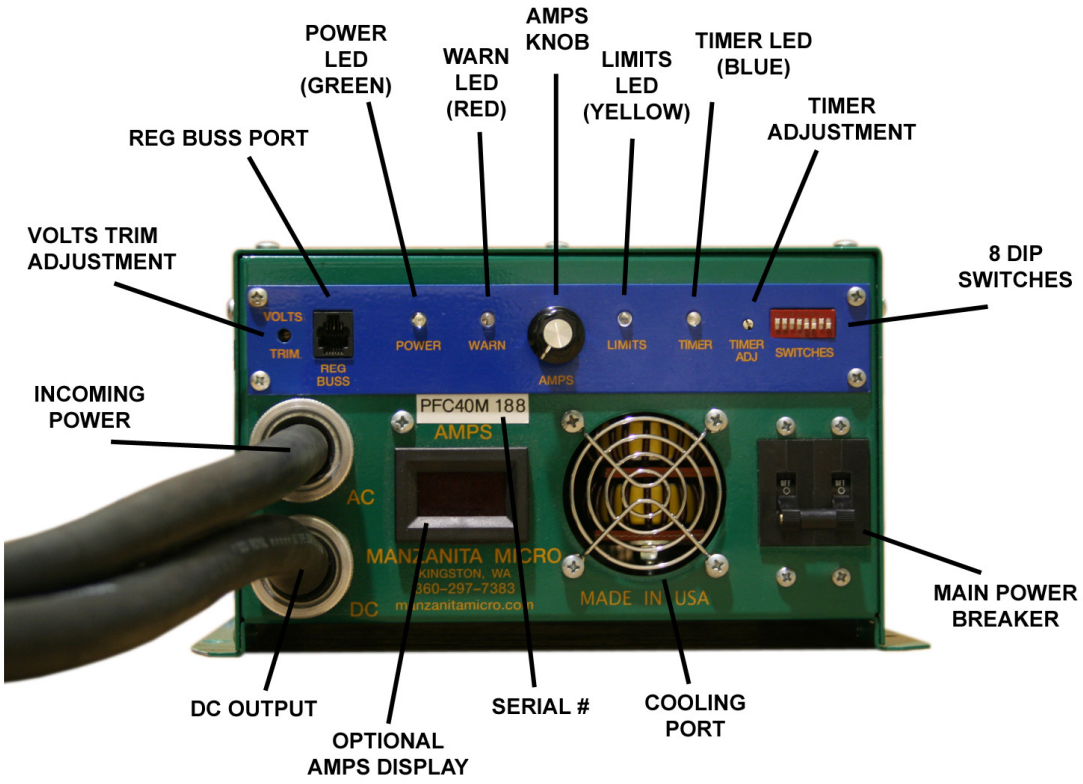


figure 02. PFC Charger Layout

Turning the Charger On and Off

There is an ON/OFF Breaker to the right of the cooling fan (or coolant fittings on liquid cooled models). This breaker is the main switch to turn the charger on or off. If ever there is a concern while charging *first* shut off this breaker switch.

NOTICE! DO NOT unplug the gray SB-50 Anderson connectors (DC line) from your charger *while it is charging*! If the battery pack is disconnected while the charger is putting out power the charger can be damaged. **Failure to heed these warnings may result in significant internal damage to the charger which is not covered under your warranty!**

User Control Panel

The user interface panel is the long blue panel with yellow text near the top of the PFC charger. The main things most users need to be concerned with are the LED indicators, the VOLTS TRIM and the adjustable AMPS knob. Below are explanations of each feature in order from left to right. Refer to *figure 02* for specific locations.

"VOLTS TRIM"

This controls the peak DC voltage ceiling that the charger will allow the batteries to reach before limiting the current. Unless specified otherwise, the voltage limit is specifically calibrated and set by Manzanita Micro to 191 Volts (for a 156V nominal pack.) In the event that adjustment is desired, please follow the instructions below. Starting in 2010, a special insulated screw driver for adjusting the volts trim is shipped with each new Manzanita PFC charger.

NOTICE! Always use an appropriately sized insulated screw driver when adjusting the voltage trim potentiometer. Suitable drivers are available for purchase from Manzanita Micro or other electronics components manufacturers. (Mouser part #: 594-8T000, Vishay/Spectrol Adjust Tool, www.mouser.com)

figure 03. Adjustment Tool # 008T000

NOTE: If the battery pack is not heated for any reason such as outdoors in a cold climate, the peak charging voltage threshold will likely need to be raised in order to assure a complete charge. This is especially true for lead acid batteries. Many users turn the volts trim maximum up during the winter and then back down to normal during the summer months. Always consult your battery manufacturer for information on the peak "fully charged" voltage specifications and how they change based on temperature.

NOTE: The peak voltage regulation set point on a Manzanita Micro charger is accurate to within 5 volts or less. Follow the "Volts Trim Calibration" instructions on the next page and make the initial adjustment with the amps knob completely down so that no current is flowing. Gradually turn up the amps knob and nudge the volts trim potentiometer up accordingly. Use caution on the first charge cycle and make sure to check that the point at which the charger volts trim limit is reached is really the correct voltage for your specific batteries.

VOLTS TRIM CALIBRATION:

Final tuning is best accomplished when the battery pack is fully charged. The lower the state of charge, the more the user will need to monitor and adjust the unit during the first charge cycle.

1. Turn the amps knob all the way down (full counterclockwise).

2. Make sure the charger is plugged into the battery pack and that there are no open breakers or open fuses in the DC battery circuit.

3. With the charger's AC breaker switch in the ***OFF*** position, plug the charger into the AC power outlet.

4. Now turn ***ON*** the charger's AC breaker switch. The fans should come on.

5. Using an appropriate insulated screw driver, stick it into the VOLTS TRIM access hole (see figure 04) and turn the internal adjustment potentiometer until you find the threshold where the yellow LIMITS LED changes state. If the yellow LED is off, turn the trim pot counterclockwise to get it to turn on. If the yellow LED is on, turn the trim pot clockwise to get it to go off. Once you find the threshold where the LED changes states, the cutoff voltage is set to the actual battery voltage and the charger will not charge the pack above this voltage. Therefore, when you are ready to charge you will need to turn the trim pot clockwise to raise this voltage ceiling. Then turn the AMPS knob up until you can put the amount of amps you want into the battery pack while not letting the batteries go over their peak voltage limit according to their manufacturer's data.

While charging, when the battery pack voltage hits the peak limit the yellow LIMITS LED will come on along with the flashing blue TIMER LED.

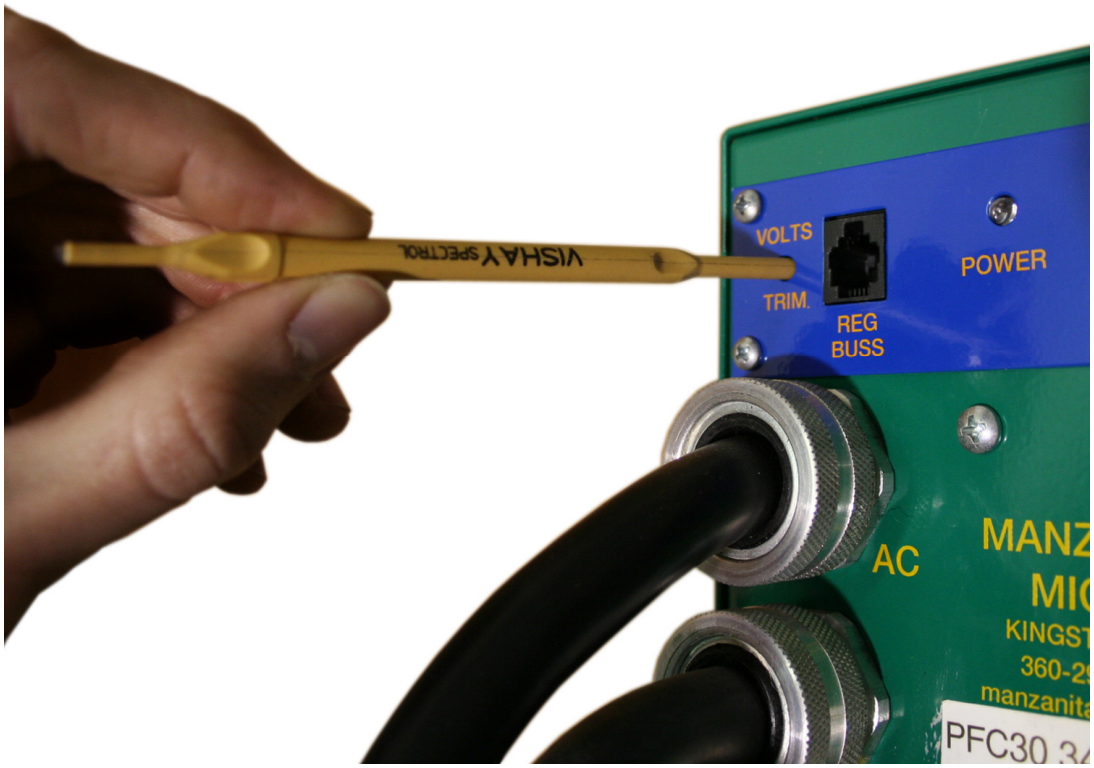


figure 04. VOLTS TRIM Adjustment

"REG BUS"

This is the 6 pin RJ jack where the BMS communication line plugs into the charger. This port allows the individual battery regulators to communicate with the charger. For more information on the specific reg bus pins refer to the "Reg Bus Wiring" section later in this manual.

NOTICE! If your vehicle is equipped with a Battery Management System, ensure that the reg bus data cable is fully plugged into the charger whenever the vehicle is charging. The communication data cables are hooked to the regulators in a daisy chain fashion. Make sure that each of the smaller data cables are all plugged in where they should be before charging. **If there is an unplugged portion of the reg bus, the charger cannot communicate with the regs and this could lead to a potentially damaging situation if there is an un-matched battery cell in the pack!** The RJ connectors are similar to phone cord connectors and they are designed to snap into place and stay connected. If a cable is disconnected insure that it is fully reconnected. An audible *click* should be heard when the RJ plug is fully inserted and it should not be able to be pulled out without first pinching the small plastic tab underneath the plug. For more information on reg bus cables refer to the "Reg Bus Wiring" section later in this manual.

"POWER" - Green LED

The bright green POWER LED indicates when the charger is on. Input power is being supplied to the unit and the main breaker is in the ON position.

"WARN" - Red LED

The red WARN LED should blink briefly when the charger is first powered up and then remain off for the duration of the charge. If this indicator stays on, turn down the AMPS knob immediately, turn off the charger's breaker switch and consult Manzanita Micro or a qualified service technician. This LED could indicate an over voltage or over temperature condition. It could also be indicative of an open circuit condition in the pack. Turn down the AMPS knob and check to make sure there is no open circuit condition in the battery pack. Check the gray SB-50 Anderson connector to insure that it is tightly connected and look for other disconnected battery cables. If the charger will not work and the circuit is complete, contact Manzanita Micro.

NOTICE! DO NOT let the charger try to put current into the battery pack if there is an open circuit condition in the circuit. Never unplug the gray SB-50 Anderson connectors (DC line) from your charger *while it is charging*! If the battery pack is disconnected while the charger is putting out power the charger can be damaged. **Failure to heed these warnings may result in significant internal damage to the charger which is not covered under your warranty!**

"AMPS" Knob

The AMPS knob allows the user to adjust how much current the charger will move. If the vehicle is always plugged in to the same circuit this shouldn't need any adjusting but if the user were to have it set at 35 amps and then plug into a 15 amp 110V outlet it will quickly open a circuit breaker or fuse on the AC line. The vehicle operator may wish to

adjust this knob when the charger is plugged in to a public outlet especially if there is no easy access to the electrical panel for that circuit. Additionally, the user might need to turn down the charger if there are other loads on the branch circuit (example: A stereo and a computer are running on the same 15 amp circuit). If using a charger equipped with the panel mount meter, the user can check the digital current meter on the front of the PFC unit and see exactly how many amps the charger is drawing off of the AC line.

"LIMITS" - Yellow LED

The yellow LIMITS LED indicates that the charger has reached its peak voltage limit. This should happen only at the end of the charge cycle when all the batteries are fully charged. The LIMITS indicator should be accompanied by the blinking blue TIMER LED which indicates that the charger is in current cutback mode and the timer is counting down to the end of charge.

If the yellow LIMITS LED is blinking, then it is indicating that there is an over temperature condition and the charger is in thermal cutback mode.

NOTE: When using regulators, the blue TIMER LED will often come on before the LIMITS LED because the battery regulators let the charger know when the batteries are getting full before the voltage limit is reached. If the LIMITS light is coming on frequently or before most of the regs are blinking, this could be indicative of a few batteries whose voltages are getting too high. It could also mean that someone has improperly adjusted the VOLTS TRIM. Consult your battery regulator user's manual or recalibrate the VOLTS TRIM setting on the charger.

"TIMER" - Blue LED

The blue TIMER LED indicates that the charge is complete or near completion. If it is flashing it means that charging is almost finished and the charger is backing off the current and counting down the timeout timer. When the blue LED is steady, it means that the timeout timer has ended and the charger has finished charging the pack. At this point the charger should be putting out no power and drawing less than an amp off the input line.

"TIMER ADJ"

This stands for timer adjustment. This is a small 16 position rotary switch which allows the user to adjust the amount of time that the charger takes in constant voltage mode, while cutting back current at the end of a charge cycle before it shuts off completely.

If the timer is ever to be changed, adjustments are as follows. If the switch is at '0' then the timer will time out instantly - do not use this setting. ('0' is the 3-o-clock position when viewed from the front). If the switch is at '1' it will go for 15 minutes before completely cutting back power. Each additional tick after '1' adds 10 more minutes to the charge cutback time. Turning the switch clockwise all the way around to the 2:30 position will give the maximum amount of time (about 255 minutes) before timeout.

To reset the timer, turn off the power to the charger and then turn it on again.

"DIP SWITCHES"

The red and white dip switch module is on the upper right end of the charger. This is a bank of 8 switches and they are numbered starting with #1 on the far right.

NOTICE! Adjusting these switches can cause the charger to perform in an undesirable manner. Please be sure you understand these switch features before changing them.

Dip Switch Guide:

1. Engages timer at peak voltage limit set point. This switch should be ***ON.***
2. Starts timer as soon as the charger is turned on. This can be used for timed charging. This switch should be ***OFF.***
3. Starts timer when the reg bus commands. This switch should be ***ON.***
4. Reg bus latch disable. As soon as a reg trips it will start the timer and the charger will back down until timeout. This should be ***ON.***
5. Low battery detection on specially equipped chargers. This switch should be ***OFF.***
6. AGM battery equalization. When using Mk2 series battery regulators, this will allow the batteries to climb to a slightly higher voltage for equalization at the end of charge. It also commands the yellow LEDs on each reg to turn on. This switch should be ***OFF.***
7. As soon as the high voltage limit is set the charger goes off. This should be ***OFF.***
8. Auto restart function. This allows the charger to restart charging when the battery pack reaches a certain set low voltage point. This switch should be ***OFF*** unless using the auto restart feature.

NOTE: Dip switch #6 can be useful if you have battery regulators because you can momentarily switch it on and the yellow lights on all the regs should come on. If any don't, you can use this feature to narrow down which reg(s) are not communicating with the charger. This feature does not work with the LT-5 Lithium regulators.

Wiring your Manzanita Micro Charger

Your PFC-20, 30 or 40 charger has two main power cables coming out of the front of the case. The top cable is for the incoming power (usually AC from a wall outlet) and the lower cable is the charger's DC output.

Connecting the Charger to the Battery Pack

Looking at the front of the charger, you will see that the lower DC output cable has a gray SB-50 Anderson connector on it. This SB-50 is quite common on EV battery chargers and we recommend that you leave this plug on the cord. The SB-50 connector has clearly marked positive and negative sides. Measure the distance from your most positive battery terminal to your PFC charger's SB-50 connector. Cut a #6 AWG or thicker cable to the appropriate length and solder or crimp the appropriate size SB-50 pin onto one end of the cable. It is recommended that you use bright orange cable with a good insulation and voltage rating in excess of your fully charged pack voltage. (Bright orange Carol brand Super Vu-Tron welding cable is an excellent solution.) Place red heat shrink or red electrical tape around the cable near each end to clearly designate it as the positive cable and then using a matching gray SB-50 connector, push the SB-50 pin end of the positive cable into the positive side of the SB-50 until it clicks and locks in place.

Measure the distance from your most negative battery terminal to your PFC charger's SB-50 connector. Cut a #6 AWG or thicker cable to the appropriate length and solder or crimp the appropriate size SB-50 pin onto one end of this cable. Place black heat shrink or black electrical tape around the cable near each end to clearly designate it as the negative cable and then push the SB-50 pin end of this negative cable into the negative side of the SB-50 until it clicks and locks in place.

figure 05

Now you should have a gray SB-50 connector with a positive and negative wire coming out. (*See figure* 05) Use the appropriate lug or connector for your battery terminal and connect it onto the other end of each cable. Connect the positive cable to the most positive terminal of the battery pack. Connect the negative cable to the most negative terminal of the battery pack.

Double check that the polarity is correct and then plug the battery pack SB-50 into the DC output SB-50 coming from the PFC charger (*see figure 06*). Now the charger is connected to the pack and you are ready to hook up the charger's input power.

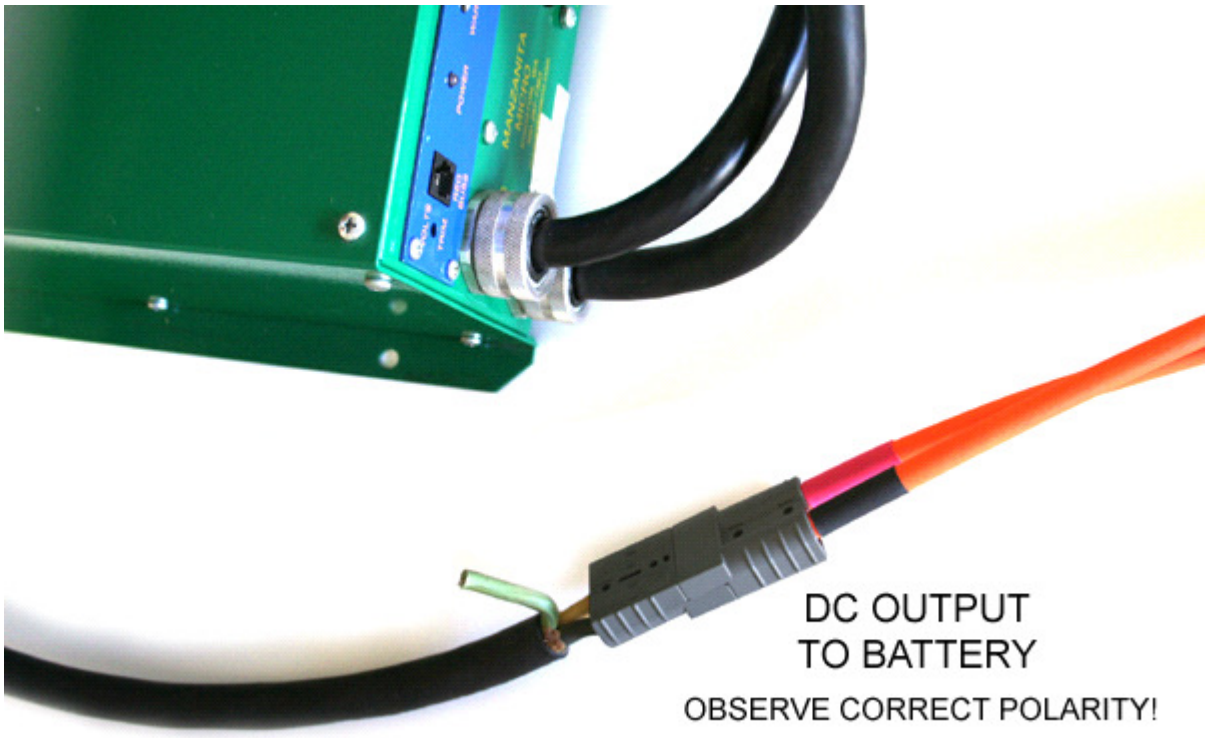


fig ure 06

Connecting the Charger to the Wall

Looking at the front of the charger you will see that the top cable is labeled AC and it is the incoming power for the charger. A great feature of the Manzanita Micro PFC line of chargers is that they are capable of operating easily off 110,120, 208, 220, 230 or 240 volts of single phase AC power. In fact they can even be run off DC (this is done in the Manzanita Plug-in Prius kits) but most users are plugging them into an AC wall outlet of some sort.

NOTE: Standard PFC-30, PFC-40 and other buck enhanced chargers must be modified to run off DC. For more information on running your charger from a DC input power source see the "Running Your PFC Charger on DC instead of AC" section later in this manual.

Ohm's law states that *Volts x Amps = Watts* of power and there are a certain number of "Watt Hours" stored in your battery pack and available to power your electric vehicle. Based on the *VxA=Watts* equation it is easy to see that more volts or amps (or both) equates to more total watts which means more electrical power moving thus faster charging.

Your Manzanita Micro PFC charger can be powered by any input voltage within the 100-240V range and there is no voltage adjustment or switches to move when changing between outlets of different voltages. The only thing which may need adjustment on the charger is the big "Amps" knob on the front. Turn this knob up or down depending on the amperage available from the outlet. With the "Amps" knob in the most clockwise position a PFC-20 can draw up to 20 amps, a PFC-30 up to 30A and a PFC-40 up to 40A.

EXAMPLE: A PFC-40 plugged into a standard 120V outlet at 15 amps would be able to draw about 1,800 watts (*120x15 = 1,800*). The same PFC-40 plugged into a 240V outlet at 50 amps could draw up to 40A so that would be about 9,600 watts, meaning a charge time that is over 5 times faster than in the 120V scenario.

PFC-20 Wiring

The PFC-20 is shipped with no connector on the AC input cable. To attach the PFC-20's input cable to a common 110/120V three prong 5-15 or 5-20 plug run the green (GND) wire to the ground prong, the white (neutral) wire to the silver screw terminal of one of the straight prongs and the black (line) wire to the brass screw terminal of the other straight prong. If you want to connect your PFC-20's input cable to a 220/240V three prong plug like a NEMA 10-30, run the green wire to the ground prong and then the white and black wires to either of the two hot prongs. You do not need a neutral wire so if you were to put another 220V plug on (such as a NEMA 14-30) you would simply connect the ground and both hot lines and disregard the neutral prong. (*See figure 07.*)

PFC-30 Wiring

The PFC-30 is shipped with a NEMA 14-30 on the AC input cable. Please leave this attached and make adapter cords if you intend to change what it plugs in to. To attach the PFC-30's input cable to a common 110/120V three prong 5-15 or 5-20 plug purchase a 14-30 receptacle and make an adapter exactly as shown in figure 07. If you wish to make an adapter cord to connect your PFC-30's input cable to a 220/240V three prong plug (like a NEMA 10-30, 10-40 or 6-50), use a 14-30 receptacle and simply disregard the angled neutral prong. Run the green wire to the ground prong and then the white and black wires to either of the two hot prongs. Since there is no neutral in the older 3 prong 220/240V plugs simply disregard the fact that your PFC charger has a 4 prong plug on it. (*See figure 07.*)

PFC-40 Wiring

The PFC-40 is shipped with a NEMA 14-50 on the AC input cable. Please leave this attached and make adapter cords if you intend to change what it plugs in to. The 14-50 outlet is very common at RV parks, electric ovens and some public charging stations.

To attach the PFC-40's input cable to a common 110/120V three prong 5-15 or 5-20 plug purchase a 14-50 receptacle and make an adapter exactly as shown in figure 08. If you wish to make an adapter cord to connect your PFC-40's input cable to a 220/240V three prong plug (like a NEMA 10-30, 10-40 or 6-50), use a 14-50 receptacle and simply disregard the middle straight neutral prong. Run the green wire to the ground prong and then the white and black wires to either of the two hot prongs. Since there is no neutral in the older 3 prong 220/240V plugs simply disregard the fact that your PFC charger has a 4 prong plug on it.

Note: Any Manzanita Micro PFC-20, 30 or 40 charger can be plugged into a NEMA 14-50 outlet. The 50 amp rating is just what the outlet is capable of and the charger will only draw as much as it is designed to use. (*See figure 08.*)

Running Your PFC Charger on DC instead of AC

You may have heard that Manzanita Micro chargers can run from both AC and DC power. This is true under the right circumstances; in fact the PFC40HM is designed to run on both AC and DC in the Pi Prius conversion kits.

NOTICE! The Manzanita Micro chargers were really designed to run from an AC power source. If you are planning to run one on DC power and it is damaged, repair work will likely **NOT BE COVERED UNDER WARRANTY! It should be noted that the primary on/off circuit breaker on the charger is only AC rated. For this reason, we recommend installing an appropriate DC rated breaker or fuse on the input side when powering any Manzanita charger with DC.**

There are three Manzanita Micro PFC charger models which can be run off DC power without having to make any internal adjustments to the unit. These unique models are the standard PFC-20, the PFC-40HM and the standard PFC-50 (none of them have buck enhancement).

If you are running a charger on DC power, it is advisable to keep the input voltage between 100 and 390VDC. The lowest voltage that will get the charger to turn on is about 60VDC. The absolute highest acceptable DC input voltage is 400V. **NEVER EVER EXCEED THE 400VDC MAXIMUM INPUT VOLTAGE!!**

NOTE: The buck enhanced chargers including the standard PFC-30 and PFC-40 and the PFC-50B and PFC-75 chargers can be modified to run on DC by disconnecting the buck sensor unit and adding a jumper over two pins on the main power board. Contact Manzanita Micro for more information if you if you are really determined to run a buck enhanced charger from a DC power source.

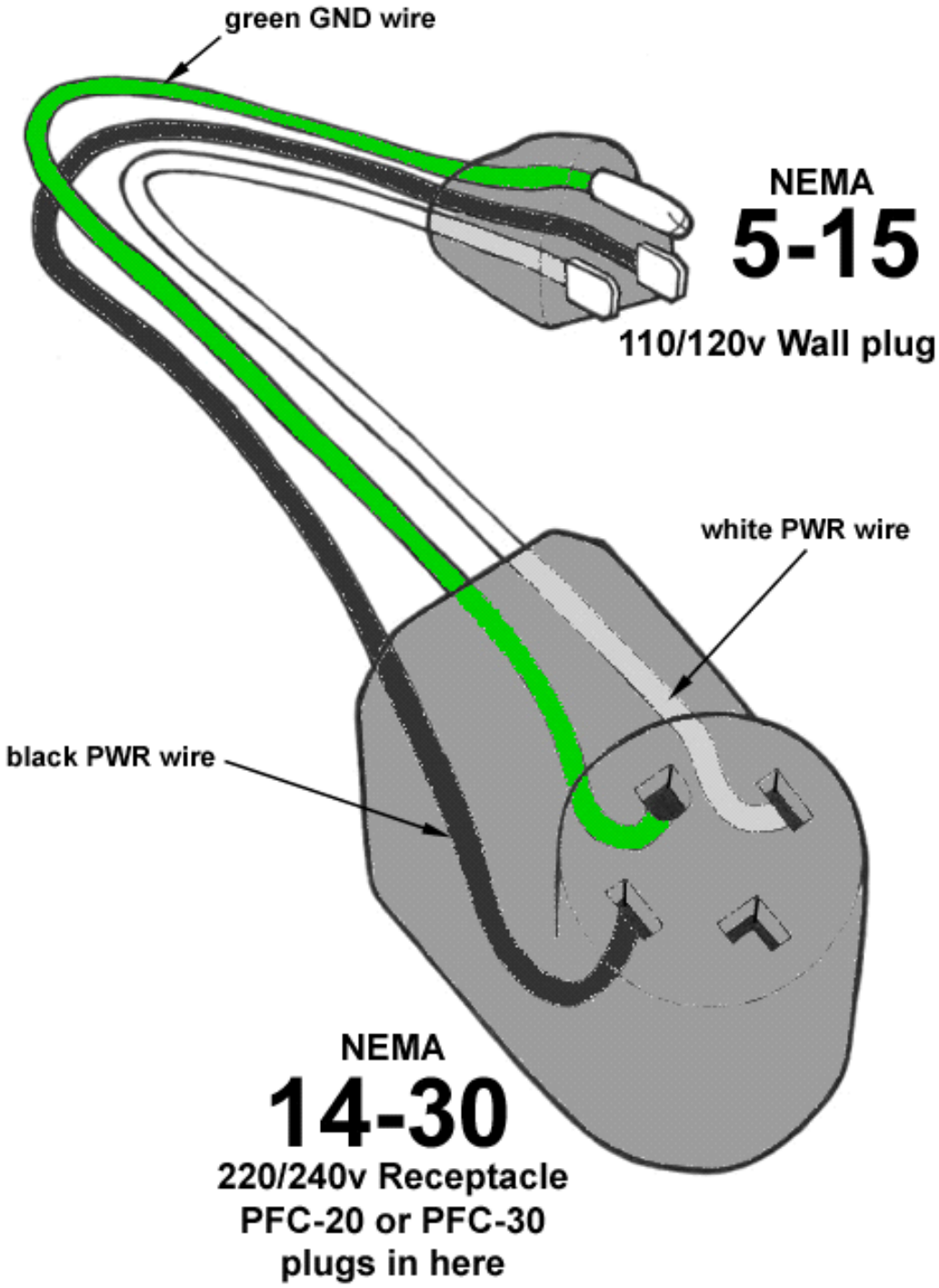


figure 07. PFC-20/30 Adapter Wiring

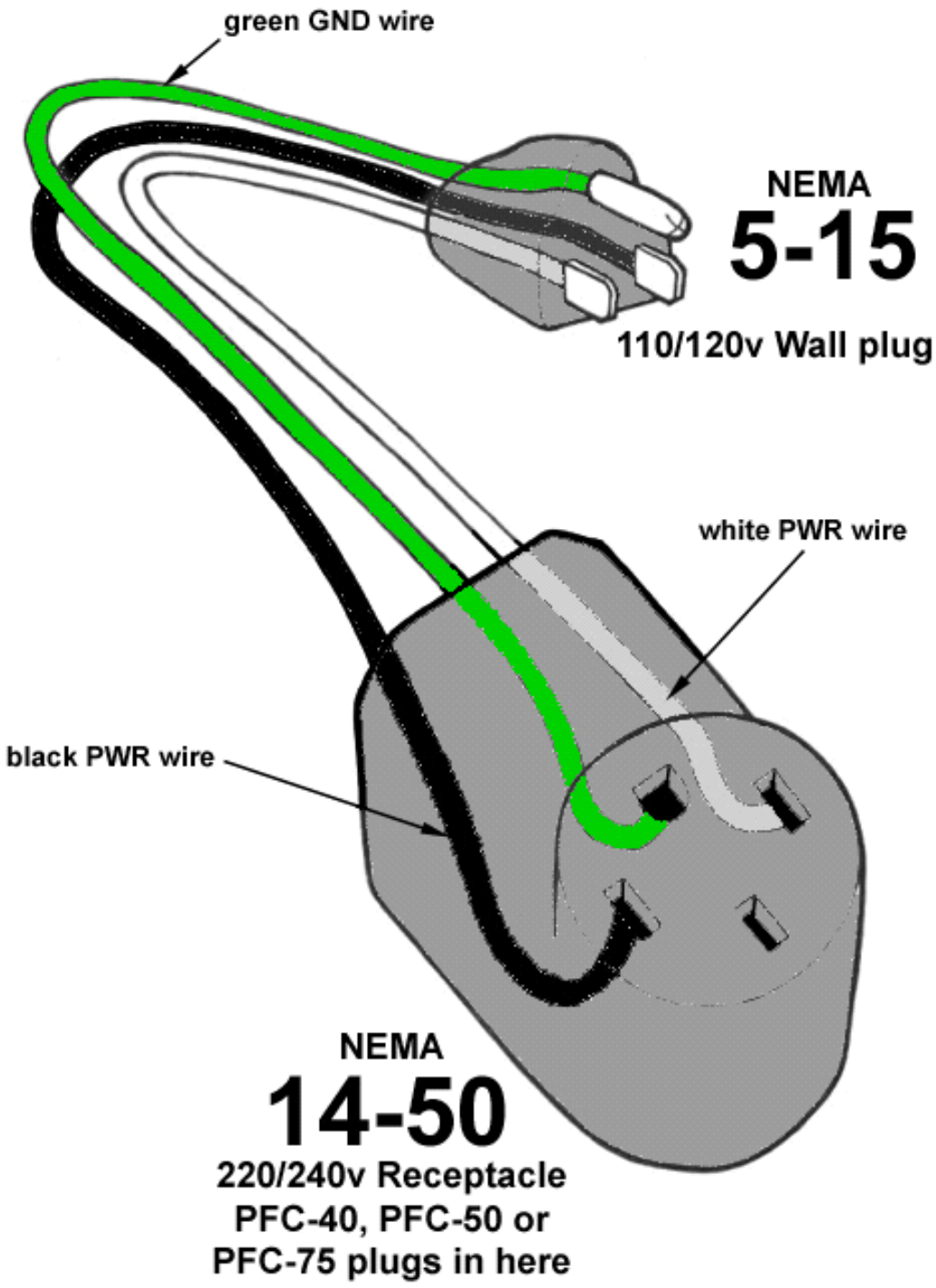


figure 08. PFC-40 Adapter Wiring

Reg Bus Wiring

The Reg Bus Interface:

The REG BUS communicates to the charger when any BMS regulators are regulating and also if any regs are too hot. The charger uses this information to determine when to turn down the charge current and when to turn off the charger.

The interface contains six wires connected with their respective pins as follows:
1. WHITE : Power supply (+5 volt DC)
2. BLACK : Reg over voltage condition (reg ON or reg hot) +5V will activate this line and tell the charger to stop charging
3. RED : Under voltage condition – 0V on this line means under voltage active
4. GREEN : Power supply return (GND) – Refers to charger's Batt Neg line

CAUTION: The GND return is NOT isolated!

5. YELLOW : Rudman bus negative
6. BLUE : Rudman bus positive

Note: The pin count reads from left to right when you are looking straight on into the RJ receptacle. Or, when viewed from the bottom of the printed circuit board, pin #1 is the square pin.

The optic components keep the local Batt POS and Batt NEG (battery or cell being monitored) isolated from the charger's Batt POS and Batt NEG. The +5 and GND are powered from a 500 mA current limited power supply. All measurements are made relative to the GND wire. It is important to verify all six of the wires are continuous throughout the system.

NOTICE! On older models the GND on the reg bus is also battery negative on a PFC charger!

The primary functions of the REG BUS are:
1. Supply power to the charger side of regs.
2. Support analog data exchange from regs to charger and analog control of charger by the regulators (or other BMS).
3. Support digital data transfer and control of regs via the Rudman Bus (modified EVILbus).

Optimally, the charger will run full current until the first regulator gets hot, then cut back to save that regulator and then watch for the last one to come up to temperature to indicate that all the batteries are fully charged. With new sets of batteries, it can take several hours for the pack to go from the first one to top off until the last one tops off. As the batteries age and become synchronized, the time is reduced to less than an hour. At the end of pack life, the time gets longer if the batteries failure mode is self-discharge.

How hot to run the regulators during the final absorption phase of charging is a function

of the ambient temperature and how fast the vehicle needs to get back into service. Higher temperatures will make the absorption phase take less time but is more risky to the regulators. When the upper thermal threshold on a regulator has been reached, the reg will pull the hot reg line to +5 volts. This will tell the charger to stop charging until the temperature of the heat sink drops below the thermal limit. Adding airflow across the regulators will dramatically help cooling the regs and speed up charge equalization.

NOTICE! Manzanita Micro strongly advises air cooling of the battery regulators for maximum dissipation capability and longevity of the reg. For more information on regulator cooling see the appropriate Manzanita Micro regulator manual for your system.

Reg Bus Cable Construction;

The 6-wire RJ cable which is used to connect the regulators is a common data transfer cable and is available at most any electronics store. The 6-pin connector plugs are usually clear and it is easy to crimp them using an appropriate crimping tool with a 6-pin die. These are also readily available.

NOTICE! RJ cable is quite rugged but take care not to cut or sharply bend (and fatigue) the cable in order to avoid errors from broken internal wires. Additionally, follow the proper cable construction techniques listed below and make sure that all the wires are installed in the correct orientation. (See figure 09.)

Proper Reg bus cable construction is not difficult but it requires keen attention to detail on the part of the person installing the plug ends onto the RJ cable. The following steps tell how to correctly make a reg bus cable suitable for use with any 6-Pin Manzanita Micro product.

Step 1: Cut the RJ cable to the desired length. It is advisable to err on the long side because each of the cable's ends will be pushed to the back of their respective RJ receptacles.

Step 2: Strip about a quarter inch of the thick "flat" outer jacket off of each end of the cable in order to expose the 6 colored wires inside. Most RJ crimping tools will have a special wire stripping section with a guide which will allow you to quickly strip the correct length of cable jacket off.

Step 3: Hold the flat RJ cable in front of you in your left hand with one end pointing towards you and one away from you.

Step 4: Looking down at the cable in your hand make sure that the end facing away from your body has the **blue wire to the right** side.

Step 5: Now take an un-crimped plug-end in your right hand and with the tang oriented on the bottom side, slide the outward facing end of the flat RJ cable into the slot in the un-crimped plug. Make sure it is not crooked and push it all the way into the un-crimped plug. (see figure 09.)

figure 09. Correct RJ Cable Orientation

Step 6: Double check that the **blue wire is to the right** side with the tang down and then take the RJ crimping tool in your right hand. With your left hand push the cable with un-crimped plug into the 6-pin die on the crimping tool.

Step 7: While using your left hand to make sure that the RJ cable is firmly held all the way into the connector, squeeze the crimping tool all the way with your right hand to complete the crimp.

If you have a clear plug-end, you can look in and make sure that each of the 6 metal pins sank all the way down into their respective wires. Give the connector a slight tug to make sure that it is adequately fastened and now you have created a proper reg bus RJ cable end.

Follow the same steps on the other end of the cable and you are done. **NOTE!** When crimping the second end of the cable, notice that you'll have to flip it over in order to **again orient the blue wire to the right when the connector tang is facing down.** (see figure 10.)

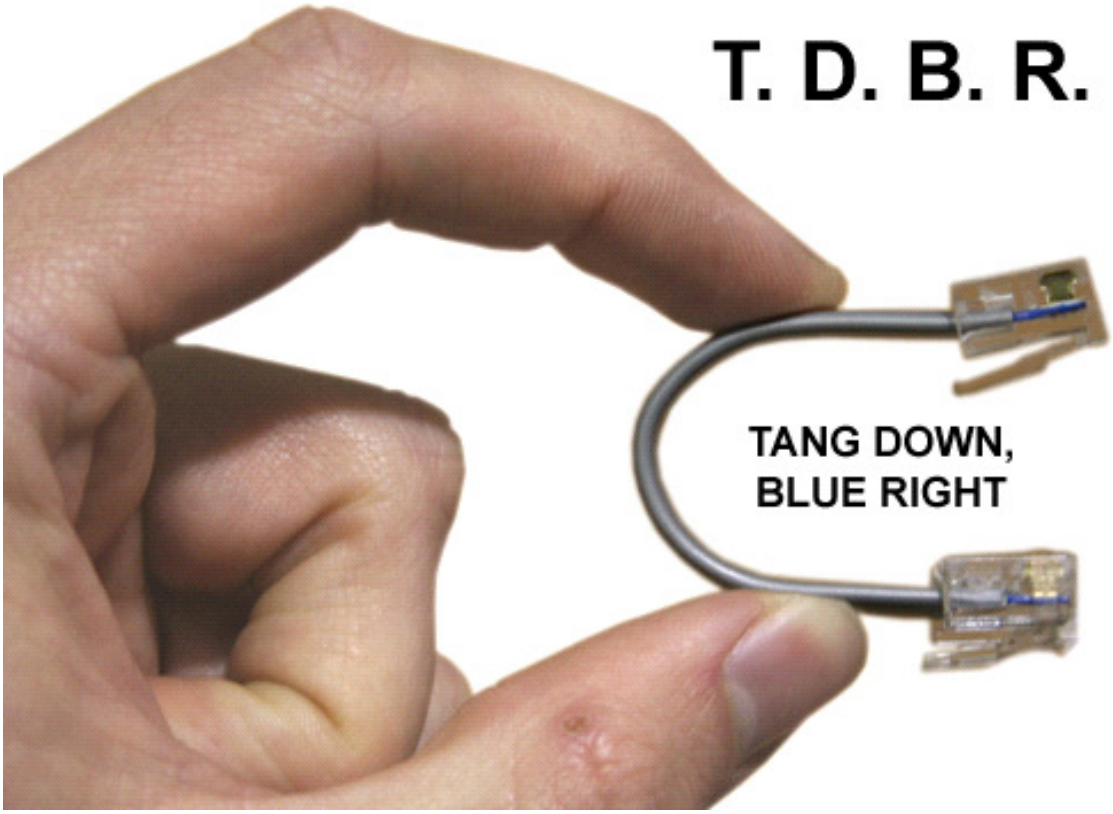


figure 10. Side View of Proper RJ Cable

For more information visit: www.manzanitamicro.com

Or for technical questions or other inquiries:

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